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(54) Fuel injector

(57) A fuel injector comprises a valve needle (14) engageable with a seating to control fuel flow from a delivery passage (18) to an outlet opening (20), a control chamber (24) communicating with the delivery passage (18), the control chamber (24) being defined, in part, by a surface associated with the valve needle (14) orientated such that the application of fuel under pressure to the control chamber (24) applies a force to the valve needle (14) urging the valve needle (14) towards its seating, a control valve (62) controlling the fuel pressure within the control chamber (24), and a delivery valve (40, 46) responsive to the fuel pressure within the control chamber (24) to control the flow of fuel along the delivery passage (18) towards the seating.

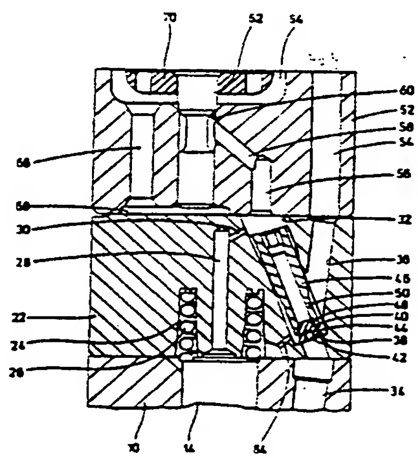

FIG 2

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Description

[0001] This invention relates to a fuel injector for use in injecting fuel at high pressure to a cylinder of a compression ignition internal combustion engine. The invention relates, in particular, to an injector intended for use in a fuel system in which a common rail or accumulator is charged with fuel by a high pressure fuel pump, a plurality of individually actuable injectors being connected to the common rail or accumulator.

[0002] Fuel injectors of this type are described in EP-A-0767304, EP-A-0798459 and EP-A-0740068. In each of these cases, the injector includes a valve needle which is spring biased into engagement with a seating. The needle includes thrust surfaces orientated such that the application of fuel under pressure thereto applies a force to the needle urging the needle away from its seating. The injector further includes a control chamber defined, in part, by an end surface of the needle. The application of fuel under pressure to the control chamber applies a force to the needle assisting the spring. An electromagnetically operated valve controls the fuel pressure within the control chamber.

[0003] Such injectors have the disadvantage that, upon actuating the valve to terminate injection, fuel injection continues at a reduced rate whilst the needle is moving towards its seating, and such continued injection causes an increase in smoke emissions.

[0004] According to the present invention there is provided a fuel injector comprising a valve needle engageable with a seating to control fuel flow from a delivery passage to an outlet opening, a control chamber communicating with the delivery passage, the control chamber being defined, in part, by a surface associated with the valve needle orientated such that the application of fuel under pressure to the control chamber applies a force to the valve needle urging the valve needle towards its seating, a control valve controlling the fuel pressure within the control chamber, and a delivery valve responsive to the fuel pressure within the control chamber to control the flow of fuel along the delivery passage towards the seating.

[0005] It will be appreciated that when injection is to terminate the control valve allows the pressure within the control chamber to rise. As a result, the delivery valve closes the delivery passage thus fuel at high pressure is no longer supplied towards the seating. Also, as the delivery passage is closed, the pressure within the control chamber rises quickly. Both of these effects result in rapid movement of the needle into engagement with its seating thus reducing low rate injection immediately before injection terminates.

[0006] The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of an injector in accordance with an embodiment of the invention;

Figure 2 is an enlarged view of part of the injector of Figure 1; and

Figure 3 is a view illustrating a modification.

[0007] The fuel injector illustrated in Figure 1 comprises a nozzle body 10 having a blind bore 12 formed therein, an injector needle 14 being slidable in the bore 12. The needle 14 includes a frusto-conical end portion 16 which is engageable with a frusto-conical seating provided at an end of the blind bore 12 to control fuel flow from a delivery passage 18 which communicates with the bore 12 towards a plurality of small outlet openings 20 located downstream of the seating. It will be appreciated that the application of high pressure fuel to the delivery passage 18, and hence to the bore 12 results in a force being applied to the valve needle 14 urging the valve needle 14 away from its seating.

[0008] The end of the nozzle body 10 remote from the openings 20 engages a distance piece 22. The distance piece 22 is provided with an annular recess which defines a control or spring chamber 24 within which a helical spring 26 is located, the spring 26 engaging an end surface of the valve needle 14 to bias the valve needle 14 into engagement with its seating. It will be appreciated that the end surface of the valve needle 14 is exposed to the fuel pressure within the spring chamber 24. The central part of the distance piece 22 acts as a stop to limit the permitted range of movement of the valve needle 14.

[0009] An axially extending blind drilling 28 communicates with the spring chamber 24 the drilling 28 communicating through a passage 30 of relatively small diameter with a bore 32. The bore 32 is arranged to communicate with a drilling 34 provided in the nozzle body 10 which forms part of the delivery passage 18.

[0010] The distance piece 22 is further provided with a drilling 36 which communicates with the bore 32, the drilling 36 forming part of the delivery passage 18. Downstream of the connection of the drilling 36 with the bore 32, the bore 32 is shaped to define a step forming an annular valve seating 38. A delivery valve member 40 of frusto-conical shape is engageable with the seating 38 to control the flow of fuel along the delivery passage 18 from the drilling 36 towards the drilling 34. As shown most clearly in Figure 2, the delivery valve member 40 is provided with a short axial drilling 42 which communicates with a radially extending passage 44 to provide a flow path permitting fuel to flow through the delivery passage 18 towards the seating at a restricted rate even when the delivery valve member 40 engages the seating 38.

[0011] The bore 32 further contains a tubular stop member 46 which is in screw-threaded engagement within the bore 32 and is located to limit movement of the valve member 40 away from the seating 38. The stop member 46 is adjustable to control the permitted range of movement of the delivery valve member 40.

The end of the tubular stop member 46 adjacent the valve member 40 is shaped to define a frusto-conical seating 48 with which the valve member 40 is engageable to control fuel flow through the passage of the tubular stop member 46. A by-pass orifice 50 is provided in the wall of the tubular stop member 46, the by-pass orifice 50 ensuring that when the valve member 40 engages the frusto-conical seating 48 fuel is still permitted to enter the passage of the tubular stop member 46 although at a restricted rate.

[0012] The surface of the distance piece 22 remote from the nozzle body 10 abuts a valve housing 52 which is provided with a through bore 54 which communicates with the bore 36 and forms part of the delivery passage 18. The valve housing 52 is further provided with a blind drilling 56, an angled passage 58 communicating with the drilling 56, the passage 58 communicating with a through bore 60 within which a valve member 62 is slidable. The valve member 62 includes a region of relatively large diameter which engages a frusto-conical seating defined around an end of the bore 60. Upstream of the seating, the valve member 62 is shaped so as to define, with the bore 60, an annular chamber with which the passage 58 communicates. Downstream of the seating, the bore 60 communicates with a chamber 64 which, in use, communicates with a low pressure fuel reservoir. The chamber 64 also communicates through a passage 66 with a chamber 68 defined between the valve housing 52 and the distance piece 22, the presence of the chamber 68 permitting free movement of the valve member 62 without resulting in the formation of a hydraulic lock.

[0013] The part of the valve member 62 located within the chamber 64 carries an armature 70 which is moveable under the influence of a magnetic field generated, in use, by an electromagnetic actuator 72 located in a bore formed in a nozzle holder 74. It will be appreciated that, if desired, actuators of other types may be used. The nozzle holder 74 is also provided with an adjustable spring abutment member 76 against which a spring 78 is seated, the spring 78 engaging an end of the valve member 62 to bias the valve member 62 into engagement with its seating. The nozzle holder 74 is further provided with drillings 80 which communicate with the bore 54 and form part of the delivery passage 18, an edge filter member 82 being located in part of one of the drillings 80. A cap nut 86 is in threaded engagement with the nozzle holder 74 and is arranged to secure the nozzle body 10, distance piece 22 and valve housing 52 to the nozzle holder 74.

[0014] In use, the part of the passage 80 upstream of the edge filter member 82 is connected to a source of fuel under high pressure, for example a common rail charged with fuel by a high pressure fuel pump. In the position illustrated, the actuator 72 is not energised, thus the valve member 62 is biased by means of the spring 78 into engagement with its seating. The spring chamber 24 is charged with fuel at high pressure, and fuel at high pressure is also present in the bore 12. The presence of fuel at high pressure in the spring chamber 24 together with the action of the spring 26 urges the valve needle 14 into engagement with its seating, the force applied by the spring 26 and the force due to the fuel pressure within the spring chamber 24 being greater than the force urging the valve needle 14 away from its seating due to the presence of fuel at high pressure within the bore 12.

[0015] In order to commence injection, the actuator 72 is energised resulting in movement of the valve member 62 against the action of the spring 78. Such movement of the valve member 62 permits fuel to flow from the spring chamber 24 to the chamber 64 and low pressure reservoir. Such flow of fuel reduces the fuel pressure within the chamber 24 thus the force urging the valve needle 14 towards its seating is reduced. Further, the fuel pressure within the tubular stop member 46 is reduced thus the force urging the valve member 40 into engagement with the seating 38 is reduced. As a result, the valve member 40 lifts from the seating 38 and moves into engagement with the frusto-conical seating 48. Additionally, the valve needle 14 lifts from its seating thus permitting fuel to flow to the outlet openings 20. It will be appreciated that fuel is permitted to flow into the interior of the stop member 46 through the orifice 50, but the rate of fuel flow through the orifice 50 is sufficiently low to have negligible effect upon the operation of the injector during this phase of the operating cycle.

[0016] In order to terminate injection, the actuator 72 is de-energized and the valve member 62 returns into engagement with its seating under the action of the spring 78. The movement of the valve member 62 prevents further fuel from flowing to the low pressure reservoir, and the continued flow of fuel through the orifice 50 at a low rate results in the fuel pressure within the tubular stop member 46 and the spring chamber 24 increasing. As the fuel pressure within the tubular stop member 46 increases, a point is reached beyond which the fuel pressure within the tubular stop member 46 is sufficient to cause the valve member 40 to move against the action of the fuel pressure in the part of the bore 32 downstream of the seating 38 to move the valve member 40 into engagement with the seating 38. Clearly, once the valve member 40 engages the seating 38 the continued flow of fuel along the delivery passage 18 is restricted, continuing fuel injection reducing the fuel pressure within the bore 12, and also that fuel can flow into the tubular member 46 towards the spring chamber 24 at an increased rate.

[0017] The continued flow of fuel through the stop member 46 results in the fuel pressure within the spring chamber 24 increasing to a sufficient extent that the action of the fuel pressure within the spring chamber 24 in combination with the action of the spring 26 is sufficient to cause movement of the valve needle 14 against the action of the fuel pressure within the bore 12 to move the valve needle 14 into engagement with its seat-

ing, thus terminating injection. It will be appreciated that the movement of the valve member 40 into engagement with the seating 38 has the effect of reducing the supply of fuel to the bore 12, and in addition allows the fuel pressure within the spring chamber 24 to increase at a greater rate than would otherwise be the case by reducing the restriction to flow of fuel towards the spring chamber 24 at this stage in the operating cycle of the injector. The valve needle 14 thus moves into engagement with its seating at a rate greater than would otherwise be the case, and continued low rate injection just prior to termination of injection is reduced. As a result, undesirable smoke emissions are reduced.

[0018] After termination of injection, the continued flow of fuel at a low rate through the passage 44 and drilling 42 provided in the valve member 40 results in the fuel pressure within the bore 12 rising to the level upstream of the valve member 40.

[0019] As shown in Figure 2, fuel is permitted to flow at a restricted rate directly from the bore 32 through a restricted passage 84 to the spring chamber 24, this flow of fuel not being via the orifice 50 and not being controlled by the delivery valve member 40. The provision of this restricted flow path ensures that, when the valve needle 14 occupies its fully lifted position in which it engages the distance piece 22, the part of the valve needle 14 still exposed to the fuel pressure within the spring chamber 24 is exposed to fuel at relatively high pressure, thus reducing the risk of the valve needle 14 becoming stuck in its fully lifted position.

[0020] In the modification illustrated in Figure 3, the delivery valve member 40 is of spherical form and, as in the arrangement of Figures 1 and 2, is engageable with an upper seating 48 defined by the tubular stop member 46, or with a seating 38 controlling fuel flow towards the drilling 34. In this embodiment, the seating 38 is formed on an insert 88 located in the bore 32. In order to permit fuel to flow past the delivery valve at a restricted rate when the valve member 40 engages the seating 38, one or more grooves 90 are conveniently provided in the seating 38.

Claims

1. A fuel injector comprising a valve needle (14) engageable with a seating to control fuel flow from a delivery passage (18) to an outlet opening (20), a control chamber (24) communicating with the delivery passage (18), the control chamber (24) being defined, in part, by a surface associated with the valve needle (14) orientated such that the application of fuel under pressure to the control chamber (24) applies a force to the valve needle (14) urging the valve needle (14) towards its seating, a control valve (62) controlling the fuel pressure within the control chamber (24), and a delivery valve (40, 46) responsive to the fuel pressure within the control chamber (24) to control the flow of fuel along the delivery passage (18) towards the seating.

2. A fuel injector as claimed in Claim 1, wherein the delivery valve comprises a valve member (40) cooperable with a first seating (38) to restrict fuel flow along the delivery passage (18) and cooperable with a second seating (48) to restrict fuel flow between the delivery passage (18) and the control chamber (24).

3. A fuel injector as claimed in Claim 2, further comprising by-pass means (42, 44) permitting fuel to flow along the delivery passage (18) at a restricted rate when the valve member (40) engages the first seating (38).

4. A fuel injector as claimed in Claim 2 or Claim 3, further comprising by-pass means (50) permitting fuel to flow to the control chamber (24) at a restricted rate when the valve member (40) engages the second seating (48).

5. A fuel injector as claimed in Claim 3, wherein the by-pass means (42, 44) comprises passage means (42, 44) provided in the valve member (40).

6. A fuel injector as claimed in Claim 3, wherein the by-pass means comprises at least one groove (90) provided in the first seating (38).

7. A fuel injector as claimed in any one of Claims 2 to 5, wherein the valve member (40) is of frusto-conical form.

8. A fuel injector as claimed in any one of Claims 2 to 6, wherein the valve member (40) is of spherical form.

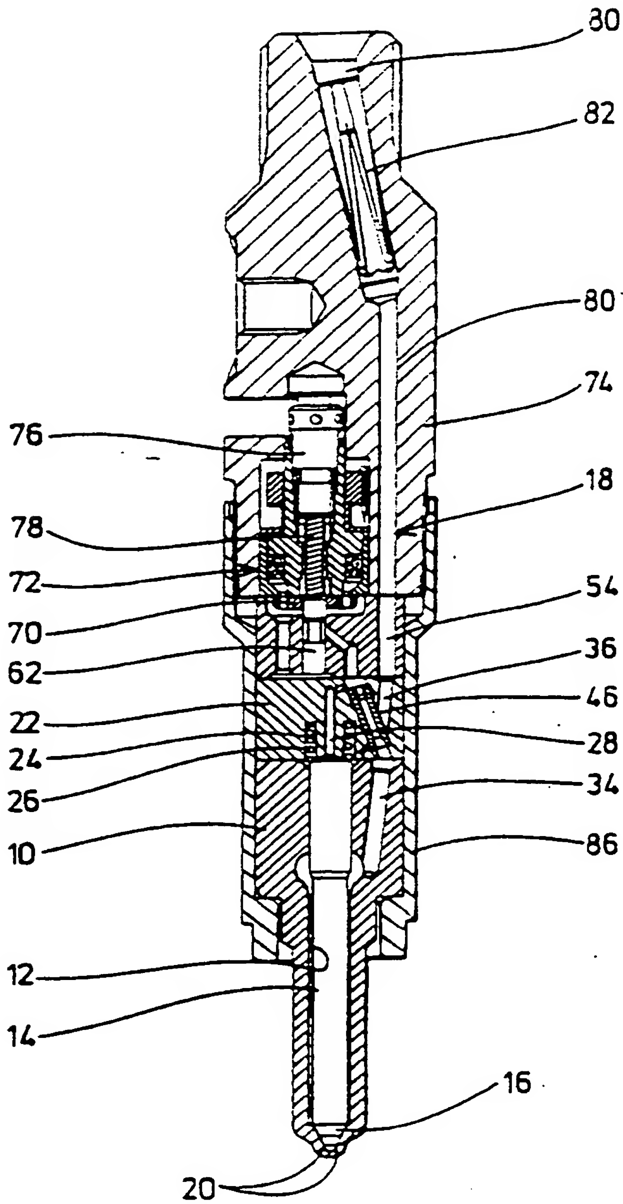

FIG 1

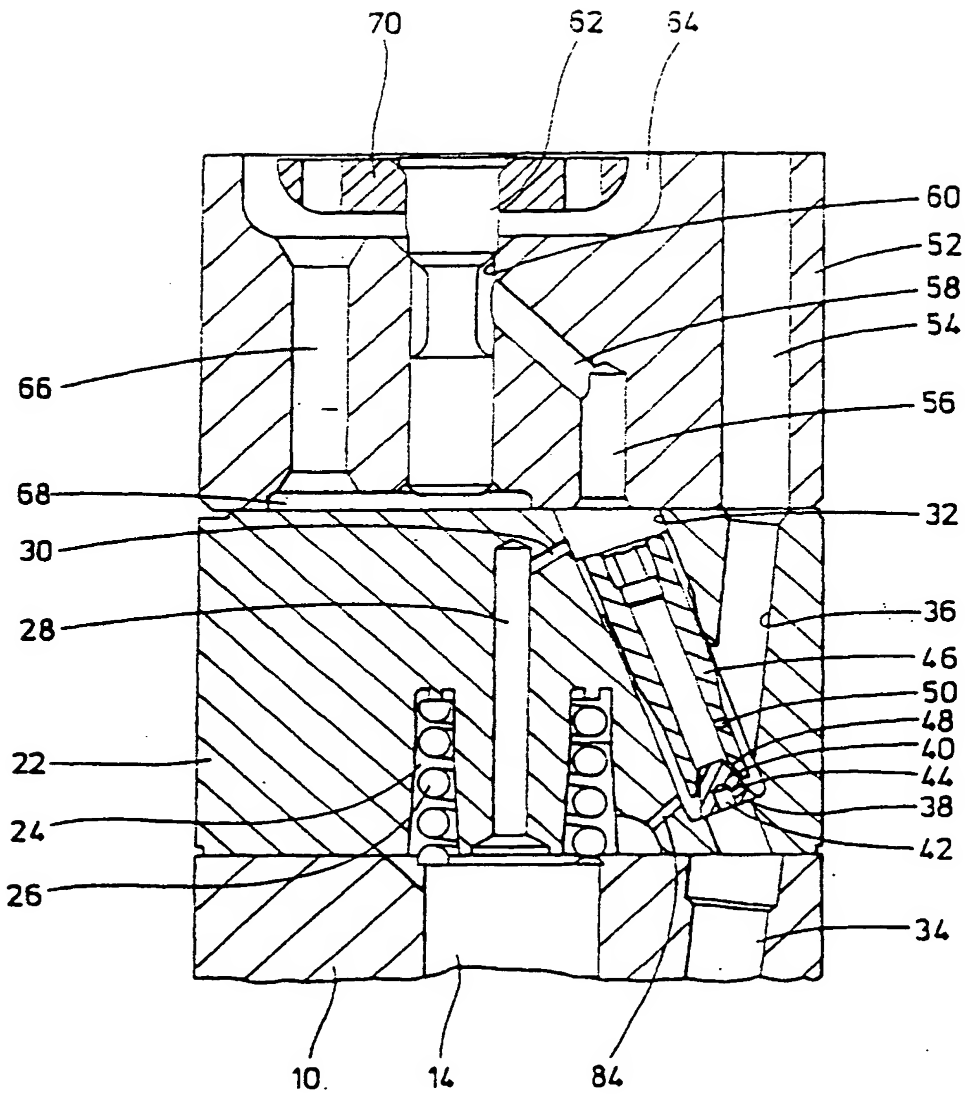
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FIG 2

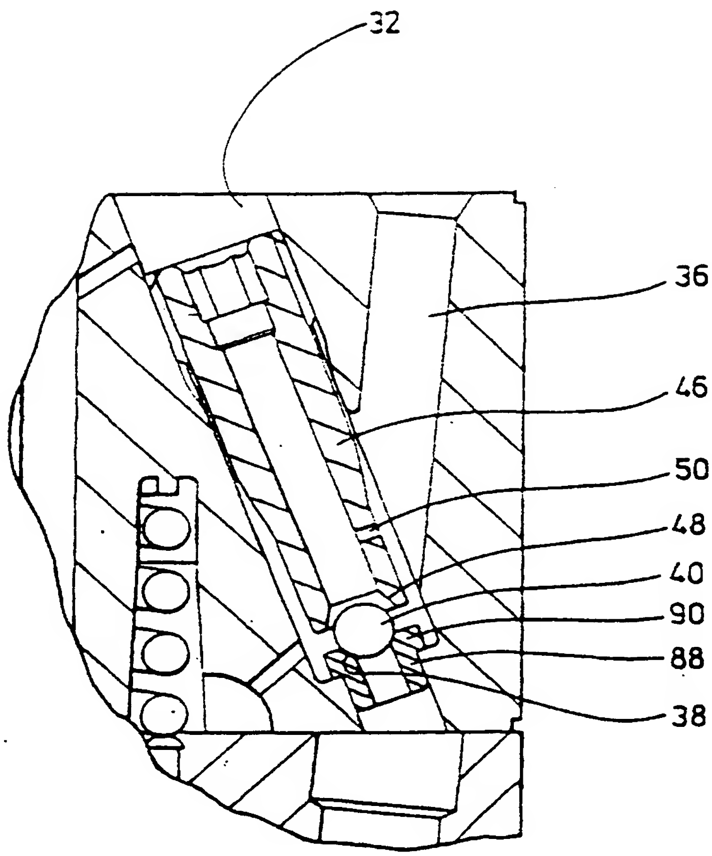

FIG 3